exposure contained DMHy and AsH_3 with the proportion identical with the atmosphere used for growing the GaInNAs layer 1905 thereon.

Page 95, line 16, through page 96, line 3:

Further, the result of FIG. 27 indicates that the GaInNAs layer 1905 contains therein a substantial amount of C, while the profile of C shows that there exists a peak of C concentration in the GaInNAs layer 1905 at the bottom part thereof adjacent to the foregoing GaNAs interface 1908. It is believed that the C concentration in the GaInNAs layer 1905 arises due to the methyl group contained in DMHy used for the source of N in the growth of the GaInNP layer 1905. The result of FIG. 27 suggests that such an incorporation of C into the III-V layer occurs inevitably when a part of the group V elements is replaced with N in the epitaxial growth process of the III-V layer.

REMARKS

Reconsideration and allowance of this application, as amended, are respectfully requested. The written description and the abstract of the disclosure have been amended. Claims 1-37 remain pending in the application, with claims 1-24 and 29-34 withdrawn from consideration as directed to a nonelected invention. The rejections are respectfully submitted to be obviated in view of the amendments and remarks presented herein.

The written description has been amended to correct the inadvertent misdescription of the layer designated by reference number 1905. The abstract of the

disclosure has been amended for improved readability. Entry of each of the above amendments is respectfully requested.

35 U.S.C. § 103(a) - Sato

Claims 25-28 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over U.S. Patent No. 6,281,518 to Sato. The Office Action acknowledges that a difference "between the instant claims and the prior art is the nitrogen overpressure before deposition," but concludes that "in the absence of unobvious results, it would have been obvious . . . to determine through routine experimentation the optimum, operable atmosphere over the layer in the Sato reference in order to prevent volatile escape and passivate the layer."

The rejection of claims 25-28 under § 103(a) as being unpatentable over Sato is respectfully traversed. For the following reasons, Sato would not have rendered obvious the embodiments of the method defined by any of claims 25-28.

Applicants' claim 25 defines a method of fabricating a compound semiconductor device. The method includes the step of "exposing a surface of said first group III-V compound semiconductor layer to an atmosphere containing N." The first group III-V compound semiconductor layer is free from N, and the resultant "second group III-V compound semiconductor layer [contains] therein N as a group V element." The claimed invention would not have been obvious because there is no suggestion or motivation,

either in the reference or in the knowledge generally available to one of ordinary skill in the art, to modify the reference to attain the claimed invention.

Specifically, there is no suggestion in Sato to modify its teaching to include Applicants' claimed step of "exposing a surface of said first group III-V compound semiconductor layer to an atmosphere containing N." Furthermore, Sato discloses a structure in which N is included in each of the layers. (See, e.g., Sato column 5, lines 59-66; column 6, lines 22-23; and claim 1 ("each of said first and second monoatomic layers includes a group III-V semiconductor alloy containing nitrogen").) According to Applicants' claimed method, however, the "second group III-V compound semiconductor layer [contains] therein N as a group V element."

Applicants disclose the rationale for, and the advantages associated with, the claimed nitrogen-exposure step (i.e., the "unobvious results" required in the Office Action) at specification page 89, line 17, through page 90, line 19:

> In the growth of a semiconductor layer on an underlying layer or substrate, the nucleation process on the underlying layer is generally an important factor. In the case of the epitaxial growth of a III-V mixed crystal layer that includes a large immiscibility gap therein, the nucleation process is believed to be a critical factor for the successful epitaxial growth. However, little investigations have been made so far on the nucleation process in the III-V system containing N.
>
> During a series of experimental investigations of growing a III-V mixed crystal layer containing N as a group V element on an underlying layer, the inventor of the present invention has discovered that the exposure of the underlying III-V mixed crystal layer, which is free from N, to an atmosphere containing

> N is effective for improving the quality of the desired III-V mixed crystal that is grown on such an underlying III-V layer.
>
> More specifically, the inventor of the present invention has discovered that exposure of a III-V semiconductor layer, which is free from N, to an atmosphere containing N induces an exchange of some of the atoms of the group V element on the exposed surface with N. Thereby, the mixed crystal layer of the desired III-V semiconductor material containing therein N is grown on such a processed surface of the underlying layer, without forming defects at the interface between the underlying layer and the N-containing epitaxial layer grown thereon.

Applicants respectfully submit that the Examiner's conclusion of obviousness is based on impermissible hindsight. The knowledge upon which the Examiner relies is gleaned only from Applicants' disclosure, since Sato is completely silent as to the claimed nitrogen-exposure step.

Claims 26-28 depend from claim 25 and are allowable along with claim 25, and on their own merits.

For at least the above reasons, reconsideration and withdrawal of the rejection of claims 25-28 under § 103(a) are respectfully requested.

35 U.S.C. § 103(a) - Sato

Claims 35-37 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Sato. The Office Action acknowledges that Sato "differs from the instant claims in the aluminum source," but concludes that "in the absence of unobvious results, it would have been obvious . . . to determine through routine experimentation the

optimum, operable source of aluminum in the Sato reference in order to decompose the aluminum while not introducing impurities."

Applicants respectfully disagree, and assert that the Examiner's conclusion of obviousness is based on impermissible hindsight. The knowledge upon which the Examiner relies is gleaned only from Applicants' disclosure, since Sato is completely silent as to the claimed steps of "using a metal organic compound of Al for the source of Al," let alone Applicants' rationale for doing so. Applicants disclose, however, that

> the existence of Al in the layer underlying the layer that contains N causes a severe deterioration in the quality of the N-containing layer grown thereon due to the segregation of N at the interface between the N-containing layer and the underlying layer. (Specification page 102, lines 11-16.)

By employing the metal organic compound of Al for the source of Al in the claimed process, Applicants are able to control the Al content of the epitaxial layers, and thus the N content thereof. (See, e.g., specification page 17, lines 9-11.)

Claims 36 and 37 depend from claim 35 and are allowable along with claim 35, and on their own merits.

For at least the above reasons, reconsideration and withdrawal of the rejection of claims 35-37 under § 103(a) are respectfully requested.

In view of the above, each of the claims under consideration in this application is believed to be in immediate condition for allowance. Accordingly, the Examiner is

respectfully requested to withdraw the outstanding rejection of the claims and to pass this application to issue.

Dated: June 19, 2002

Respectfully submitted,

By _____

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Version With Markings To Show Changes Made

In the Abstract of the Disclosure:

Please amend the abstract as follows:

An optical semiconductor device operable in a 0.6 μm band includes an active layer of GaInNP sandwiched by a pair of GaInP [layer with] layers each having a thickness of about 2 molecular layers or less.

In the Written Description:

Please amend the written description to as follows:

Page 93, line 3, through page 94, line 11:

After such an exposure of the GaAs layer 1904 to the atmosphere containing N, the growth of the GaInNAs layer 1905 is conducted on the foregoing modified surface 1908 by supplying TMG, TMI, DMHy and AsH_3 respectively as the source materials of Ga, In, N and As. As noted previously, the temperature of the epitaxial growth for the [GaInNP] GaInNAs layer 1905 is set to about 600°C, wherein it should be noted that the N content in the layer 1905 is increased when the substrate temperature is reduced or the supply rate of DMHy is increased, or the deposition rate is increased. When the deposition temperature is high, the group V elements, particularly N, escape easily from the deposited epitaxial layer. Further, it should be noted that the foregoing epitaxial growth of the GaInNAs layer 1905 is restricted by the bottle-neck process of supplying of the group III elements. Thus, whenever the supply of TMG and TMI is started, the growth of the GaInNAs layer 1905 occurs on the modified surface 1908 of the GaAs layer 1904. As the

surface 1908, on which the growth of the GaInNAs layer 1905 occurs, already has the composition of GaNAs, the growth of the GaInNAs layer 1905 occurs without forming defects at the interface between the layer 1904 and layer 1905, and the GaInNAs layer 1905 is grown with substantially free from defects.

In the foregoing experiments, the process of modifying the surface 1908 of the GaAs layer 1904 was conducted by exposing the surface of the GaAs layer 1904 to the atmosphere containing N for about 30 seconds, wherein the atmosphere used for the exposure contained DMHy and AsH_3 with the proportion identical with the atmosphere used for growing the [GaInNP] GaInNAs layer 1905 thereon.

Page 95, line 16, through page 96, line 3:

Further, the result of FIG. 27 indicates that the GaInNAs layer 1905 contains therein a substantial amount of C, while the profile of C shows that there exists a peak of C concentration in the GaInNAs layer 1905 at the bottom part thereof adjacent to the foregoing GaNAs interface 1908. It is believed that the C concentration in the [GaInNP] GaInNAs layer 1905 arises due to the methyl group contained in DMHy used for the source of N in the growth of the [GaInNP] GaInNAs layer 1905. The result of FIG. 27 suggests that such an incorporation of C into the III-V layer occurs inevitably when a part of the group V elements is replaced with N in the epitaxial growth process of the III-V layer.